pressure on the diaphragm has been reported to cause pleuritic pain, dyspnea, lower lobe atelectasis, and recurrent pneumonias.[8] The most immediate and life-threatening problem associated with a splenic pseudocyst is spontaneous rupture, which occurs in about 25% of cases.[9] A patient with a ruptured splenic pseudocyst presents with hemoperitoneum and shock and requires immediate surgical intervention. For this reason it is advisable to remove these cysts at the time of diagnosis, even in an asymptomatic patient.

Differentiating splenic cysts from other intraabdominal visceral cysts can sometimes be difficult. The differential diagnosis would include omental and mesenteric cysts, as well as cysts of the left kidney, liver, pancreas, left adrenal gland, and left ovary. Ultrasound study, computed tomographic scan, and liver-spleen scan are all helpful in making the diagnosis. Routine abdominal radiographic films may detect splenic cyst calcifications; however, these may be difficult to distinguish from splenic artery aneurysms.[8]

If a patient has a history of exposure to an animal carrier or has lived in areas where echinococcosis is endemic, it is necessary to consider echinococcal infection. This infection can result in the formation of splenic cysts similar in appearance to pseudocysts; injury to such cysts during laparotomy may cause intraabdominal dissemination of echinococcal scolices. Echinococcal cysts of the spleen generally arise on the upper pole and if calcified, the rim tends to be less dense and incomplete compared to nonparasitic cysts.[4] If echinococcal cysts are suspected, a serum complement fixation test can be helpful.[1]

There is some controversy regarding the treatment of splenic cysts. Recommendations range from simple observation to splenectomy. In 1950, Fowler popularized splenectomy as the treatment of choice, reporting a minimal mortality rate.[1] With further evidence of the spleen's role in immunosurveillance, there has been an increasing emphasis on splenic salvage, especially in pediatric patients. Cyst excision or splenorrhaphy can be considered if the cyst does not involve the splenic hilum and if there is a major division in the extrasplenic blood supply.[10] Partial cyst excision and marsupialization is another option. The two patients in our series had large splenic pseudocysts. In one patient a cyst excision was done and the spleen salvaged. In the other the cyst occupied a large portion of the spleen, and its position in the splenic hilum necessitated splenectomy. It would be prudent, however, to attempt splenic preservation when feasible either by splenorrhaphy, cyst excision, or drainage and marsupialization.

REFERENCES

1. Fowler RH: Nonparasitic benign cystic tumors of the spleen. Inter Abst Surg 1953; 3:209-227

2. Garvey JW, Peyser I, Delany HM: Traumatic cyst of the spleen: An unusual presentation. J Trauma 1971; 11:974-979

3. Humphreys WG, Johnston GW: Splenic cysts: A review of six cases. Br J Surg 1979; 66:407-408

4. King MC, Glick W, Freed A: The diagnosis of splenic cysts. Surg Gynecol Obstet 1968; 127:509-512

5. Roberson F: Solitary cysts of the spleen. Ann Surg 1940; 111:848-850

6. Langley JR: Splenic cyst: Report of a case with review of the literature. Am J Surg 1977; 3:171-174

7. Qureshi MA, Hafner CD: Clinical manifestations of splenic cysts—Study of 75 cases. Am J Surg 1965; 9:605-608

8. Sweet RH: Single true cysts of the spleen. N Engl J Med 1943; 22:705-710

9. Eisenstat TE, Morris DM, Mason RG: Cysts of the spleen: Report of a case and review of the literature. Am J Surg 1977; 134:635-637

10. Sink JD, Filston HC, Kirks DR, et al: Removal of splenic cyst with salvage of functional splenic tissue. J Pediatr 1982; 3:412-414

Acute Renal Failure Due to Rhabdomyolysis Associated With Cocaine Toxicity

JANE LOMBARD, MD
San Francisco

BRANDON WONG, MD
JEFFRY H. YOUNG, MD
San Jose, California

ACUTE RENAL FAILURE due to rhabdomyolysis has been reported with the use of amphetamines, heroin, and phencyclidine hydrochloride. Despite the recent upsurge in popularity of cocaine as a "recreational drug," however, there has been no report of myoglobinuric renal failure associated with cocaine abuse. We describe the case of a patient in whom rhabdomyolysis and renal failure developed after numerous intranasal doses of cocaine over several days. The clinical aspects of this case are similar in many respects to those of rhabdomyolysis associated with phencyclidine or amphetamine abuse.

Report of a Case

A 33-year-old, previously healthy man was admitted for bizarre behavior and fever. The patient was noted to be increasingly despondent recently. He had been a cocaine user "off and on" for about ten years. During the three days before admission he began using 10 to 14 grams of cocaine intranasally daily. Subsequently he became very agitated and delirious. He locked himself in his room, refusing to communicate with his family or to eat or drink. In the night before admission to hospital, the patient was reported to be yelling, barking, and running into the walls.

Physical examination revealed a temperature of 40°C (104°F). The blood pressure was 140/90 mm of mercury with a pulse rate of 120 per minute and a respiratory rate of 32. The patient was severely agitated and had babbling speech. At times he required restraints, yet he was alert and oriented. Multiple ecchymoses were present throughout his body. Laboratory data included a serum creatinine value of 2.5 mg per dl, blood urea nitrogen of 26 mg per dl, and the initial creatine kinase was 514 IU per liter. The serum calcium was 7.0 mg per dl and serum albumin, 3.3 grams per dl. Serum phosphate was 3.8 mg per dl and the potassium was 4.7 mmol per liter. The leukocyte count was 18,400 per μl with 76% granulocytes, 18% lymphocytes, and 6% monocytes reported by the automated cell differentiator. The hematocrit level was 48% with a hemoglobin concentration of 16.3 grams per dl. A urinalysis showed a moderate amount of ketones and 4 to 10 granular casts per high power field. Initially the dipstick revealed no blood, but subsequently it did so in the absence of microscopic hematuria. Urine myoglobin was present in a concentration of 11.9 μg per ml. Urine and blood toxicology screens confirmed the presence

(Lombard J, Brandon W, Young JH: Acute renal failure due to rhabdomyolysis associated with cocaine toxicity. West J Med 1988 Apr; 148:466-468)

From the Division of Nephrology, Department of Medicine, Santa Clara Valley Medical Center, San Jose, California. Dr Lombard is currently affiliated with the Department of Cardiology, Saint Mary's Hospital, San Francisco.

Reprint requests to Jeffry H. Young, MD, Department of Medicine, Santa Clara Valley Medical Center, 751 S Bascom Ave, San Jose, CA 95128.

of cocaine as well as of its urinary metabolite, benzoylmethylecgonine. No other drugs were identified.

Therapy consisted of vigorous intravenous fluid replacement, 25 grams of mannitol, and sedation with diazepam (Valium) and haloperidol (Haldol). The patient remained nonoliguric; however, on the second hospital day, the serum creatinine level peaked at 3.9 mg per dl and the blood urea nitrogen at 34 mg per dl. The serum creatine kinase reached a peak of 57,300 IU per liter (normal range, 16 to 195) with 98.2% MM fraction on isoenzyme determination. Clinically the patient improved rapidly. His fever subsided and his agitation abated. He was discharged on the fourth hospital day with a serum creatinine value of 2.7 mg per dl and a blood urea nitrogen concentration of 17 mg per dl. Unfortunately, the patient was lost to follow-up.

Discussion

Cocaine, an alkaloid derivative of the plant *Erythroxylon coca,* has long been used for medical and cultural purposes. Recently the use of cocaine as a stimulant and euphoric agent has greatly increased. With its popularity, there have been many reports of various complications associated with cocaine toxicity. Acute myocardial infarction, with and without atheromatous coronary artery disease,[1-5] ventricular dysrhythmias,[6] renal infarction,[7] bowel ischemia and infarction,[8,9] pulmonary dysfunction,[10] and subarachnoid hemorrhages[10] have thus been reported. Rhabdomyolysis with acute renal failure, however, has not been previously associated with cocaine intoxication. Nontraumatic rhabdomyolysis and acute renal failure have been reported in association with a number of commonly abused drugs.[12,13]

Rhabdomyolysis seen in association with heroin and barbiturate abuse is probably related to local pressure necrosis from the patient's own body while the patient is obtunded or unconscious.[14] Rhabdomyolysis has also been associated with phencyclidine use.[15-17] This has been postulated to be due to muscle damage caused by the use of restraints in a hyperactive, combative patient.[16] Others have proposed that the acute dystonic reaction induced by phencyclidine caused the muscle damage.[17] Amphetamine abuse has also been associated with rhabdomyolysis and acute renal failure.[18-20] Hyperpyrexia and increased muscular activity seen in these patients have been considered important in causing the muscle damage.[19] Cocaine is unique among the local anesthetics in its ability to enhance the effects of sympathetic stimulation. The action of epinephrine and norepinephrine is terminated with the uptake of these drugs at the adrenergic nerve endings. Cocaine blocks this uptake, thus prolonging the effects of catecholamines. Cocaine also facilitates norepinephrine release, activates tyrosine hydroxylase, and produces an increased β-receptor density. With ongoing use, both α- and β-receptor sensitivity is increased.[21,22] Consequently, with cocaine toxicity, features of sympathetic overactivity appear, such as dilated pupils, tachycardia, hypertension, and intense vasoconstriction.[23] Cardiac lesions found in cocaine abusers are histologically similar to those seen in patients with excess catecholamine stimulation, as in those who have pheochromocytoma or have received large amounts of catecholamines during a cardiopulmonary resuscitation.[24] In the central nervous system, cocaine initially acts as a stimulant and then as a depressant. This central stimulation, as well as a cocaine-induced elevation in circulating catecholamines, leads to increased motor activity, which initially is well coordinated. When lower motor centers are affected, however, uncontrolled tremors and convulsive movements may result.[21] This increase in motor activity with a concomitant vasoconstriction that decreases heat loss may result in hyperpyrexia.

In the case described here the elevated serum creatine kinase (57,300 IU per liter) and the myoglobinuria (11.9 μg per ml) support the diagnosis of rhabdomyolysis. The intranasal doses (10 to 14 grams per day) reportedly taken by this patient before admission are extremely high when compared to the 1 to 32 grams per week range given in the national survey of the National Institute on Drug Abuse by the 800-COCAINE helpline callers.[22] As a chronic user, our patient may have been more sensitive to the sympathomimetic effects of his cocaine binge preceding admission.

Several possibilities may account for rhabdomyolysis in association with cocaine consumption in this patient. It is possible that the sympathetic overactivity resulted in vasoconstriction. The vasoconstriction in the setting of muscular overactivity may have resulted in microinfarctions with skeletal muscle necrosis. Hyperpyrexia with fluid losses and inadequate replacement may have also participated in the end result of acute renal failure. Alternatively, cocaine intoxication is known to cause seizures.[25] It is possible that while locked in his room the patient may have had unobserved seizures as the cause of rhabdomyolysis.

Phencyclidine-related rhabdomyolysis may be more likely to occur in the case of a hyperactive patient who is placed in restraints. The patient described here was agitated and required restraints at times; however, the need for restraints was not a major part of his clinical course, as so often is the case in patients intoxicated with phencyclidine. We certainly could not exclude traumatic rhabdomyolysis as a cause of his muscle damage. His history of running into the walls of his locked room and multiple ecchymoses on his body support the possibility of traumatic rhabdomyolysis. He did not, however, have obvious areas of myoedema or massive ecchymosis. Finally, the possibility that large doses of cocaine may have a more directly toxic effect on skeletal muscle in vivo cannot be excluded. Catecholamine excess seems to cause myofibrillar degeneration in humans and experimentally in animals.[26] More recently, investigators have described similar changes in myocardial muscle of cocaine abusers.[24] The initial negative finding of the benzidine urine dipstick at a time when the creatinine concentration was already elevated is compatible with rhabdomyolysis-associated acute renal failure. Creatinine often has an initial rapid rise due to the release of creatine from damaged muscle and its subsequent conversion to creatinine. Creatine kinase levels, on the other hand, usually peak on the second or third day, followed by a decline of 50% every 48 hours.[27] It is thus a more sensitive indicator of rhabdomyolysis than the presence of myoglobinuria. The absence of myoglobinuria in many cases of rhabdomyolysis-associated renal failure may suggest that other nephrotoxic products are released from muscle or, alternatively, that myoglobin excretion may be brief[27] and intermittent in view of the varying glomerular filtration rate and perfusion to damaged muscles.

The above case represents an association of cocaine intoxication and rhabdomyolysis with myoglobinuric renal failure. It has similarities with amphetamine- and phencyclidine-associated rhabdomyolysis, which also induce sympathetic overactivity. We report this case to draw attention to the

potential risk of rhabdomyolysis in cocaine intoxication. Further reports and studies may define the incidence and circumstances of occurrence of this additional deleterious effect of cocaine abuse.

REFERENCES

1. Kossowsky WA, Lyon AF: Cocaine and acute myocardial infarction—A probable connection. Chest 1984; 86:729-731

2. Howard RE, Hueter DC, Davis GJ: Acute myocardial infarction following cocaine abuse in a young woman with normal coronary arteries. JAMA 1985; 254:95-96

3. Wetli CV, Wright RK: Death caused by recreation cocaine use. JAMA 1979:2519-2522

4. Fischman MW, Schuster CR, Resnekov L, et al: Cardiovascular and subjective effects of intravenous cocaine administration in humans. Arch Gen Psychiatry 1976; 33:983-989

5. Iswer JM, Estes NAM III, Thompson PD, et al: Acute cardiac events temporally related to cocaine abuse. N Engl J Med 1986; 315:1438-1444

6. Benchimol A, Bartall H, Desser KB: Accelerated ventricular rhythm and cocaine abuse. Ann Intern Med 1978; 88:519-520

7. Sharff J: Renal infarction associated with intravenous cocaine use. Ann Emerg Med 1984; 13:1145-1147

8. Nolbandian H, Sheth N, Dietrich R, et al: Intestinal ischemia caused by cocaine ingestion: Report of two cases. Surgery 1985; 97:374-376

9. Fishel R, Hamamoto G, Barbul A, et al: Cocaine colitis: Is this a new syndrome? Dis Colon Rectum 1985; 28:264-266

10. Itkonen J, Schnoll S, Glassroth J: Pulmonary dysfunction in 'freebase' cocaine users. Arch Intern Med 1984; 144:2195-2197

11. Lichtenfeld PJ, Rubin DB, Feldman RS: Subarachnoid hemorrhage precipitated by cocaine snorting. Arch Neurol 1984; 41:223-224

12. Koffler A, Friedler RM, Massry SG: Acute renal failure due to non-traumatic rhabdomyolysis. Ann Intern Med 1976; 85:23-28

13. Grossman RA, Hamilton RW, Morse BM, et al: Non-traumatic rhabdomyolysis and acute renal failure. N Engl J Med 1974; 291:807-811

14. Chaikin HL: Rhabdomyolysis secondary to drug overdose and prolonged coma. South Med J 1980; 73:990-994

15. Akmal M, Valdin JR, McCarron MM, et al: Rhabdomyolysis with and without acute renal failure in patients with phencyclidine intoxication. Am J Nephrol 1981; 1:91-96

16. Lahmeyer HW, Stock PG: Phencyclidine intoxication, physical restraint, and acute renal failure: Case report. J Clin Psychol 1983; 44:184-185

17. Cogen FC, Rigg G, Simmons JL, et al: Phencyclidine-associated acute rhabdomyolysis. Ann Intern Med 1978; 88:210-212

18. Kendrick WC, Hull AR, Knochel JP: Rhabdomyolysis and shock after intravenous amphetamine administration. Ann Intern Med 1977; 86:381-387

19. Ginsberg MD, Hertzman M, Schmidt-Nowara WW: Amphetamine intoxication with coagulopathy, hyperthermia, and reversible renal failure—A syndrome resembling heatstroke. Ann Intern Med 1970; 73:81-85

20. Scandling J, Spital A: Amphetamine-associated myoglobinuric renal failure. South Med J 1982; 75:237-240

21. Goodman L, Gilman A: The Pharmacologic Basis of Therapeutics, 6th Ed. New York, Macmillan Publishing, 1980, pp 307-309

22. Gold MS, Washton AM, Dackis CA: Cocaine abuse: Neurochemistry, phenomenology, and treatment. Natl Inst Drug Abuse Res Monogr Ser 1985; 61:130-150

23. Pearman K: Cocaine: A review. J Laryngol Otol 1979; 93:1191-1199

24. Tazelaar HD, Karch SB, Stephens BG, et al: Cocaine and the heart. Hum Pathol 1987; 18:195-199

25. Jonsson S, O'Meara M, Young JB: Acute cocaine poisoning—Importance of treating seizures and acidosis. Am J Med 1983; 75:1061-1064

26. Reichenbach DD, Benditt EP: Catecholamines and cardiomyopathy: The pathogenesis and potential importance of myofibrillar degeneration. Hum Pathol 1970; 1:125-150

27. Knochel JP: Rhabdomyolysis and myoglobinuria. *In* Suki WN, Eknoyan G (Eds): The Kidney in Systemic Disease, 2nd Ed. New York, John Wiley & Sons, 1981, pp 268, 281